Proceedings: Eighth International Space Syntax Simposium.
Santiago, PUC, 2012.
PAPER REF # 8035

ORGANIC AND INORGANIC OVERLAPPING IN OLD BARCELONA

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KEYWORDS: *Urban morphology, Local and Global Scale, Space Syntax, Spatial sustainability, Old Barcelona*

THEME: Historical Evolution of the Built Form

ABSTRACT

Barcelona's rapid growth prompted by the Cerdà Plan produced a fast expansion on the nearby plane, whilst the urban patterns in the Ancient City were left aside, owing partly to differences in economic protocols applicable to the planning process in both areas that neglected its complexity for decades. A layout of narrow alleys and high density characteristic of the old quarters was pointed out as the cause of decay, low hygiene, misery and delinquency, together with low income rates and marginality, for which a change was sought through several plans.

The opening of new ways altered the medieval pattern of streets, lines of growth, connections to the old city core and removed commercial and gathering centres, whilst fostering new organic patterns. The tendency towards rational global planning affected the Ancient city leaving aside the local scale, where we find a recurrent design tendency to solve through clearance. An apparent conflict is then present when dealing with different layouts developed according to different logics: an organic layout and a sort of collage city that must come to terms with tracings produced for a larger, metropolitan context. Which has been the effect of these changes regarding the urban patterns?

Cartography from 18th and 19th Century has been applied to detect and compare organic and non organic layouts of the urban grid, the city plan in the past and as it exists today, selecting the streets with higher connectivity and integration values as forming a super-grid, following their evolution in a diachronic process. Space Syntax Second order measures (intelligibility and synergy between local and global scale) are then applied to the processes. Correlation values and regression lines are studied and evaluated, isolating only the main old lines of access in the initial stages that have persisted in later development, so that the different states are counterpoised, comparing values of regression for the whole area (global) and for the lines selected, so that we can evaluate how their contribution to the overall layout changes through time. We also take into account the nature of the local and global measures concerning urban centralities or patchworks given by the urban system and its trend uses; a second reading of the first set of values can then be obtained, questioning the consistency between real centralities and trivial ones,as well as the relation and limits of the different metric and topometric radii.

The comparison of integration and intelligibility detects alternative patterns of movement, their relation with new centralities, and empirical data to contrast research advanced by other authors. The old core or super-grid can be seen quite clearly, suggesting the relevance to maintain and improve its integrative qualities from which the whole area can benefit, throwing some light on the superimposition of organic layouts and recently planned interventions that aimed to preserve the urban qualities.

1. INTRODUCTION: CONTEXT AND EXCHANGES

Barcelona is an open matrix of exchanges, a diversity of systems in continuous interaction. Out of the three alignments that affect the original settlement at a global, territorial or local state (i.e, the Pyrenees, the central Catalan depression and the coastal chain of mountains), the latter determines exchanges,'*on one side it raises a barrier along the Mediterranean and, at the other, conditions the fundamental ways for the circulation Sud-West/North-East*' (Vilar 1986), even in infrastructural undertakings today.Besides thatSW-NE mobility,circulation leading to and from interior territories, natural flow of watercourses and people towards the sea,nearby refuges, a port andvantage pointsfor observation and defence offered all traits forsettlements found along the East coast, complementing conditions of the Old City.

The first Roman lattice of streets was continued on the plane by the centuriation of the area, thus installing an urban regularity that signalled future planning. "*In fact, the horizontal axial order (NW-SW) and the vertical (SE-NE) will be interpreted in an analogous way during the 19th century by Cerdà in his plan as the master axes to colonize the Barcelona plain... aqueducts and sanitary systems organized the central urban space up to the Middle Ages. The territorial structure was already established from roman ways with their bridges and paved roads that guaranteed the army's displacement but also the commercial and administrative traffic'* (Busquets, 2004, Solà-Morales 1988).

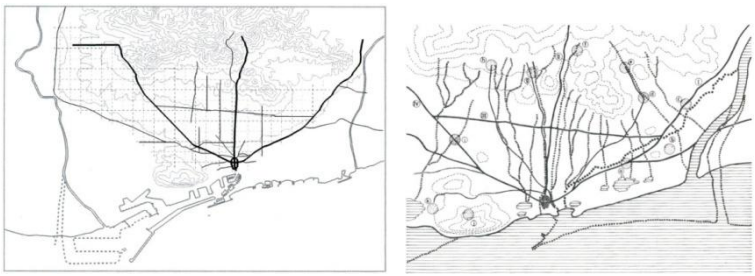

Fig. 1.Centuriation of Roman Barcelona and relation of main ways and rain watercourses, guiding movement. Thoroughfares induced later growth (see a straight natural line used as Via Augusta).Source: Busquets 2004. Garcia-Espuche, Guàrdia 1986

Despite these precedents theoriginal pattern of streetswas lost by the 11th century, with a regression of public domains. The existing wall provided protection and attraction to strangers, increasingcontrastsbetween inside and outside with the development of agriculture in open areas, and commerce by the beginning of 12th century. Some thoroughfares and naval strength appeared increasing up to mid 14th century. The Mercadal (market) led to burg activity, witheconomic and demographic growth: new (gothic) wallsprovided cohesion, shown in new institutions and tasks of citizens'representatives.

2. ELUSIVE ORGANIC CITY: A PROCESS ON THE MOVE

The term 'organic' alludes to something in constant activity and a degree of randomness, left to evolve as the functioning of its system or fate establish (Vance, 1977; Karimi 1997). The search for the organic nature of cities isa quest for reality. A first diagnose of problems in Old Barcelona was produced in the early 1980's: '*A scan of Raval, Saint Catherine or Gràcia shows without any doubt that the most obscure and degraded areas coincide with ludicrous alignments of avenues and streets, unbuildable for obvious reasons (technical, economical, social, political and managerial), and meanwhile, they are nothing but powerful seeds of un-urbanity*' (Bohigas 1983). Thus, small grain projects requiring concrete informationwere fostered instead of abstract planning distant from the citizens' daily-life, direct experience of the city. The implications concern the basis of knowledge:*"the knowledge that comes out of policy research is in the wrong shape to serve the knowledge needs of*

this sector. It is nonspecific, too lacking in detail, and too little oriented to the variables that designers and developers can manipulate, namely the physical and spatial variables of the built environment itself" (Hillierundated).

Following the qualities suggested by Karimi 1997to evaluate an organic settlementwe consider: first, the initial layout, that was a small grid no larger than 300 by 500 metres, in whichmovement through the lines of access was more important for future growth than the respect for an established grid, eventually expanding up to an area of 2000 by 1000 metres, signalling areas for specialized activities, producing an increasing land value and marking the path for densities; in second place, the duration of the process of natural growth, thatconsidered here depends on cartographic information of the first organic state, concentrating later in a series of stages separated 150 years in the most recent sequence, in fact, a diachronic sequence in which organic and inorganic structures overlap, physically and conceptually, leaving the series open to the inclusion of further studies; thirdly, the scale of development, small looking at the physical domain described above.

A differentiation between order and structure, where "*principles based on some generally accepted notion*" –regularity, symmetry, grid, etc- contrast with structure, that "*makes places intelligible through creating local differences which give both a sense of identity and a grasp of relation between the parts and the whole*" (Hanson 1989). Such relationis important when topological and metric arguments are mixed, to discard supposed inconsistencies, sinceline graph analysis does internalise the geometric properties of space into the graph, thus picking up"*the nonlocal, or extrinsic, properties of spaces that are critical to the movement dynamics through which a city evolves its essential structures. Nonlocal properties are those that are defined by the relation of elements to all others in the system, rather than intrinsic to the element itself*"(Hillier B. 1997).

Since cities are neither perfect grids nor trees (Figueiredo, Amorim 2007) we must distinguish their variety: a sense of hierarchy and continuous recursions perceptible in organic patterns.The number of topological operationsis oftenlimited, recursions numerous and indicative of special phenomena. Out of the span of possible combinations, we can question why the implemented organizations and their qualities appear, and why other possible structures do not emerge.Thus, physicalentities do not represent the crunch of urbanity; rather, the immersion into the system of space made possible by them is revealing, when some light is thrown at the changes in the grid spatial structure, optimising its functional logic (Hillier and Penn, 1992).

The study of cities by means of graphs, and the use of networks to analyse interconnected spaces created by built blocks reported by several authors (Martin& March 1972, Steadman 1983, Hillier and Hanson 1984, Jiang and Claramunt 2002, Figueiredo and Amorim 2007, Blanchard and Volchenkov 2008), interest us here for what they share.Ties between events as well as the physical background and the social network lead us to some precisions on the notions of duality and overlapping. Since any city or any artefact that houses human activity must be developed upon oriented surfaces, the primary graph that represents the physical network must be planar (and "*a graph is planar if and only if it has a combinatorial dual*" according to Whitney, as Harary 1972, p.115 collects). Such planarity affects both the study of settlements and their representations. But duality affects our approach in other senses: secondary graph representations are often not planar (requiring some simplification or further elaboration) and require agreements inconfigurations related with social networks.Comparisons between physical background and social exchangeopenthe issue of mapping between urban layouts and social networks and their comparability; then, relations between eventscan be referred to as overlapping or interlocking, adding senses to functional or graph represented entities.

The small scale of CiutatVella (Old Barcelona) adds another concern: "*There are two reasons why we must expect an agreement between angular (or topological) and metric measures. The first is what we might call the* ***averaging effect****: that with the increasing number of segmentswith increasing radius, the differences in segment lengths average themselves out, so that the total segment length very closely approximates simple segment count. Simple segment count is, as Dalton shows (Dalton 2005), the strongest component of the integration measure with restricted radius. The second reason for the closeness of the two measures is what we might call the overlapping effect: with increasing radius the radius fields from the different root segments overlap with each other, so increasingly overlapping groups of segments are being used to calculate*

the measure. So in a significant sense, least angle or topological integration measures contain more useful metric information than their metrically weighted versions" (Hillier, Turner, Yang, Park 2007). This fact leads to compare topological integration with different radius in all the stages studied, check their consistency with the antecedents (comparing axial and segment maps, and the information that reached us from historical or socio-economic data); in a second part the data can be correlated, questioning up to what extent the medieval super-grid has disappeared and, finally, deal with the sequence of patchworks revealing small scale morphologies.

3. SYNTACTIC ANALYSIS OF ANTECEDENTS: HIERARCHY AND RECURSIONS

The series of layers (antecedents) superimposed in CiutatVella (Old City), show an interplay that showed through the years recursive growth processes (Hillier, Hanson, 1984), with distinctive relations.

A Roman *castrum*, as a block closing an internal grid disposed around a Forum, established the location of institutions, then as today, correspondingtorecursions Z6, Z5 and Z7 (Hillier, Hanson, 1984), compatible with the crossing of two main streets, that linked spaces of trade and social exchanges with the routes towards the imperial roads and close cities. Theplane of Boqueria, today Rambles' meeting point, offers great centrality and integration in all axial maps studied, being the intersection of movementstowards institutions and trade located at its Centre, and towards sacred or religious centres, located at its North. Barcino was a small construction, controlling the plane between seashore and mountain and neighbouring areas. It sorted rain watercourses, two flowing along South West flank and a lesser known flowing by the North East flank outside the wall, reminding the topography presented by little Mount Tabor (15 metres above sea-level), origin of the settlement.

New constructions sprung along the main routes as Vilanoves (New towns), *open clusters* deriving towards *clumps* (Hillier-Hanson Z1 Z3), whose traces are perceived in the integration maps of local areas, i.e. of small radius (r 70), chosen for its correspondence with 45 medieval canes, a most common unit in medieval contracts.They help to understand its evolution, next tothe main connectionsfrom edge to centre and viceversa. A'live centrality' emerged where spatial and functional aspects of the urban process are twined, evolving towards the wall's Eastern vicinity, withagriculture and housing density increasing consistently around the market place, at the Plaça del Blat, today's Angel's Square (Fig 2b).

Fig. 2 a, b, c, d. Roman Barcino, according to Granados 1993. Barcelona main axes and Quarters crossing at Plaça de l'Angel centre of the active city. It changed to SantJaume, new centre, in the 15th century, and a redistribution (2 d)generated in 1770 a fifth quarter (Raval). The chunk of the City cut off by the Citadel introduced further unsolved complexity. See the curved link from St. Anthony's Gate to New Gate operating as topological distributor.Sources: Puig, Rodà_ MUHBA 2010;Brotons 2008.

A diagrammatic description of the four quarters of the city was inscribed onto a stone left there, with a significant inclusion of names and two-dimensional guidance: the city was described as used by the people and not according to the Roman two-axial traces. Thoroughfares to the City centre operate as movement guidelines involvinggates and landmarks and the edges of the existing four neighbourhoods linked to institutional or religious places. Clear details of the morphogenesis, socio-

economy and urban policies in medieval Barcelona are provided by intensive research, allowing us to reconstruct movement patterns, roles of main institutions and the overall urban dynamics (Garcia Espuche, Guàrdia M., 1986; Busquets J., 2006).

'Live centrality' stressed by Gothic precincts, followed concentric recursions Z4 (Hillier, Hanson 1984) acting from three initial stretches –between 1260 and 1295- until the late inclusion of Raval and defences against sea-storms, finished in 1495. As the old port was built, an expansion of the city opened, underlining the city's maritime connections; a new shipyard was built at the SW, giving way to the restructuring of the Seashore public spaces and institutions, especially the Guild and Customs house. The Cathedral, the Royal Palace, as well as the House of the One Hundred Counsellors offer a triangle of intertwined representations and spatial domains. New requirements, as the Hospital of the Saint Cross, between the two main ways of access to the city from the West indicate the initial function of Raval as domain for unwanted functions, a localarea of exclusion for pragmatic purposes.

Barcelona attempted to reach the maximum of space with the minimum of structure. And, as in other cities of this period, we find three forms of relations between the control of territory, the exercise of authority and a response vindicating rights: "*firstly, as the central space of a local economy; secondly, as nodes within a trans-local network of cities and capital circulation; and thirdly, as formations potentially subjected to an Estate power of territorial character*" (Tilly 1990, Sassen 2010).

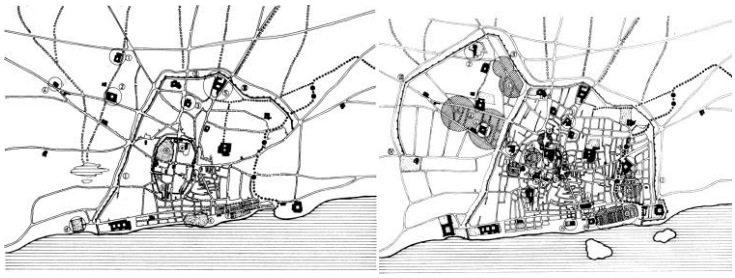

Fig. 3Barcelona in 1300 and 1400, showing Gothic walls begun 1260, 2ond sector 1275, 3rd sector 1286-1295. Source: Garcia-Espuche, Guardia, 1986.

Despite its fortifications, Barcelona wasnot well equipped for war andfell to Bourbon rule in 1714,being a captive city (1714-1860), controlled and bombarded from two citadels. Data from the 1716 Property Registrar show the locations of specialized professions (Street Argenteria and vicinities,area with high connectivitythat has since diminished a 3 %) orthe location where higher tax payers lived (Ribera, close to the seashore and Argenteria –orange line in figure 2b). The chunk of city cut-offleft extra complexities unsolved: the four original divisions of the City in the 14th Century (St. Peter's, Sea, Friars', St. Mary of the Pine) were re-arranged in 1770 into five (Fig 2d), introducing doubts between the Roman and medieval axes.As the 18th Century advanced, the number of convents and monasteries in the Northern part of the City increased, forming large aggregates surviving till the 1980's, requiringplanning interventions.The process started in early 19th Century by confiscating convents into public or cultural spaces (The Royal Square or The Great Theatre of Lyceum were two such cases). The closure of the city was unbearable, especially when bombarded from the Citadels; the citizens wanted to destroy the walls, and it finally happened just 150 years ago.

The introduction of Street Ferran (Fig.4 a, b) began a process of changes, altering the synthetic intensified grid, followed by Via Laietana (Fig.4c, d), both considered similar actions, despite their conceptual differences and effects on the urban layout. This first intervention included oppositions: between the new transversal axis and the old one, and that of the existing centres, forcing their rearrangement and new movement patterns. More relevant are the confronted topologies and their cognitive implications. Notice the proximity of Pla de la Boqueria (figure 4b), today's Meeting Point, central in all Axial and Segment maps: random walks from NW or SW lead to it. The new square (SantJaume) provides the alternative to switch to

the new Street rather than continue strolling about following the natural topography. The segments that form this way are subtle on site and the overall perception is that of a straight line, were it not by the presence of the immediate axis.

Fig.4 a, b, c, d. Ferran Street clearance: the transversal axis (Ferran Street) was the first important urban intervention in the 19th century. A first stretch (1) started in 1821 that included and followed Trinity Square (4). A second (2) and third (3) sections followed, including SantJaume Square (5) and the Angel's square, going up to the Esplanade, next to the Citadel. Via Laietana constructed between the Eastern Sector and the very centre: the organic tissue is dismantled introducing a fast traffic road and the area is divided into three sectors..Source: Busquets 2004, Brotons 2008,Busquets 2006.

The most interesting period for the next development of Barcelona and the instruments applied to study the existing conditions start in 1855 with the realization by I. Cerdà of a Plan of the surroundings of the City of Barcelona, indicating the villages nearby, at scale 1:5000, plus some Statistic Survey, and the Advancement of a Project of Enlargement, lost today. His assistants (J. Fontserè, a young S. SanpereiMiquel, who published Old topography of Barcelona: environments of Corbera in 1890, with a reconstruction of the Ribera neighbourhood recently found) made possible the next stage, in which Cerdà's topographic task was continued by Garcia Faria for the links between built areas and suburbia, and by Garrigai Roca in what concerned the alignments of the old City, realized between 1959 and 1861.

Cerdà considered this area from inception, treating the existing fabric as part of his proposals. Prior to applying DepthMap, the corresponding DXF lets us read on the topographic levels a dialogue between Cerdà's apparently alien morphology and the existing villages in the plane. The combination of morphologies HH Z5 and Z7 -central space and ring street-, carefully treated to absorb the constructions already existing, characterize this period. Many points of interest for a Space Syntax study of Barcelona, are provided byCerdàin his General Theory of Urbanization out of which we underline the plural centrality of the links with existing villages, the inseparability of layouts and circulation and, asit has been reported (Guàrdia, Monclús, Oyón 1994), district locations of high tax-payers, than in our analysis coincide with highest integration areas, moving from east to centre and north towards Cerdà's enlargement.

Old Barcelona's actuality offers difficulties inthe coexistence of several cultures, petty crime next to cultural institutions.Successions of Plans tried (Cerdà 1859, Baixeras 1888, Darder 1918, GATCPAC 1932, Florensa 1893-1930, General Metropolitan Plan of 1976 and Special Plans of Interior Reforms -PERIs from the 1980's) cover all the area with superimposed interventions.A rationalist initiative (Fig 6 c) set the recent path, an area divided in three parts, separated by the Rambles and Via Laietana in North-South direction, and in two (now three) parts by the axis of Street Ferran going East-West (and Cathedral Avenue).The clearing of areas lowered density withchanges in the patchworks, in local and global integration of the whole, concentrating of centralities.

4. METHODOLOGY ANDUSE OF DATA FROM SUCCESSIVE STAGES IN THE OLD CITY LAYOUT

Our aim is an evaluation of performance and spatial usage in successive stages.Since ecological demand on land area is much greater than the area itself, and the preference for density and compactness revised and corrected is a feature in the case of study, reawakening street culture is unavoidable. "Some *kinds of structure brought to light by syntax seem already to bethe product of interaction between environmental, economic and social factors, that is, betweenthe three principal domains of sustainability*", and we arein front of an initial requirement – *the understanding of spatial complexity of real cities as a first step to understand their spatial sustainability*in self-organised cities.At a considerably smaller scale than in London, a system of"urban villages" was implicated in Barcelona from its origins, with themes of Spatial Syntax –v.g. the paradox of centrality- renewed: having provided impetus for a metropolitan area, the centre seems to require a new reading, asHillier 2009describes*:"a foreground network of linked centres at all scales set into a background network of largely residential space, seems already to be created by the interaction of economic and social factors, against a background of the minimisation of the energy required for movement through the creation of what we might call general accessibility".*With two new concepts required: "*The first is pervasive centrality, meaning that the function of centrality in cities pervades the urban grid in a more intricate way than has been thought, and that multi scale centrality should be seen as a pervasive function in cities, with clear spatial correlates, and not simply as a hierarchy of locations. The second is the concept of fuzzy boundaries (Hillier et al 2007), meaning that urban areas are created through spatial differentiation, so maintaining inter-accessibility between areas, rather than through well defined boundaries which limit inter-accessibility. Both pervasive centrality and fuzzy boundaries are in principle naturally sustainable forms relating economic and social activity to space in a way which minimises travel distances".*

An urban grid can be decomposed in axial maps with*"the minimal set of the longest straight lines of unobstructed movement that crosses and interconnects all open spaces in the system (Hillier and Hanson, 1984)".*They are graphs where nodes are lines and edges are intersections between lines, i.e. secondary graphs developed from standard primary graph representations.Axial maps present universal, across scales, trans-cultural features in the distribution of line lengths*,* and *"in any axial map, there are a large number of short lines and a small number of very long lines*" (Hillier, 2002; Carvalho and Penn, 2004); the latter constitute a background which identifies the small scale exchanges; the former, the structuring lines.

Supposed inconsistencies in axial technique havecaused the revision of details in original theoretical models.*"The use of straight lines is oversensitive to small deformations in the grid, (…) this creates an artificial differentiation between straight and curved or sinuous paths that have the same importance in the system. Long straight paths, represented as a single line, are overvalued compared to curved or sinuous paths as they are broken into a number of axial lines" (*Figueiredo and Amorim, 2005*)"*. And this is our case.Two dichotomies (between static and dynamic, local –immediate neighbourhood- and global properties constructed with all vertices) provide a model from which to obtain measures for analysis by means of programs developed to apply Space Syntax, as expressed in diagram 1 (Hillier 1987).

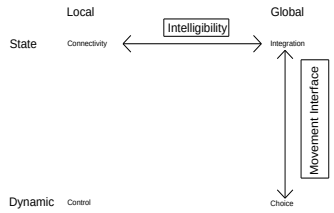

Diagram 1. B. Hillier 1987

The basic local static measure is connectivity: "*total number of nodes at radius 1*", how many other lines are only one step away from each line (i.e. immediately connected to it). The system of study reaches a critical point when density diminishes, ina contradictory situation where sponging the layout allows higher connectivity by enhancing the main lines of a super-grid.

Local dynamic measures are control, (Hillier Hanson 1984), that can be linked to clustering coefficient and controllability: *"for control, each location is first assigned an index of how much it can see, the reciprocal of its connectivity. Then, for each point, these locations are summed for all locations it can see* " (Turner 2004: Depthmap 4. A researcher's Handbook). Itdefines the area of the current neighbourhood with respect to the total area of the immediately adjoining neighbourhood: the originally tight layout has been transformed into a sparse area. The notion of control expanded by those of Clustering coefficient **(**Watts &Strogatz 1998) and ControllabilityTurner (2001b)could ascertain the existence of 'small worlds' and how the visual information is changing, since a high density of junctions has been altered by wide avenues, and nodes and connectivity diminished.

The "global dynamic" measure is "choice": '*how likely a location is to be passed through) on all shortest routes from all spaces to all other spaces in the system'*(Hillier et al**,**1986a). And the*"global state measure is integration: essentially, how many other lines are up to **n** stops away from each line*" (Hillier 1987).

Second order measures in the form of Pearson product moment correlation coefficients (r) have been used: "intelligibility" (correlation of connectivity and integration) indexes the degree to which the number of immediate connections a line hasare a reliable guide to the importance of that line in the system as a whole. A series of implications offer relevance: when locally well-connected lines are also integrating lines, then the correlation will be strong and the system will have "intelligibility", indicating that the whole can be read from the parts. And conversely, if well connected lines are not also integrating lines, then the correlation will be poor, and the whole will not be readable from the parts:*"integration" and "intelligibility" are key properties of urban layouts";* besides, *"the pattern of pedestrian movement is determined in the first instance by the pattern of "integration", and the overall density of pedestrian movement by the overall degree of integration of the area… Densities of movement in urban spaces are determined in the main by the relation of spaces to the layout as a whole, and only secondarily by the local properties of the space, or location of facilities"; "reduction in overall densities is strongly associated with loss of integration, and reduction in the predictability of the pattern of movement from the layout is strongly associated with the loss of "intelligibility"(*Hillier 1987);*"integration leads to intelligibility, and intelligibility leads to a stronger "movement interface" between inhabitants and strangers"*(B. Hillier, 2002, p. 238).Integration as indicative of graph general structural qualities has been recently reported (Blanchard, P.,Volchenkov, D., 2008).

Correlation between integrationand choiceinforms about the accessibility of a space as destination from all others and the likelihood of being a shortest routes destinyfrom all points to all other points in the layout, i.e. it indexes the agreement between a space's potential for *to-movement* and *through-movement.*

The preference for integration reported by several authors:"*the degree to which a space is likely to lie on the shortest routes from all points to all other points in the layout is not an intuitable property of the layout, whereas the number of steps a space is from all other spaces is an intuitable property in that knowledge of it can be built up over time by moving around the layout".Choice may be a better predictor of movement for "inhabitants" with better knowledge of the layout than for "strangers" who rely on reading the layout, in order to move around (*Hillier 1987, 2009*).*

5. AXIAL MAPS: DATA AND FINDINGS FROM 1439, 1714, 1858, (1932), 2009 CONFIGURATIONS

The parameters shown in Table 1 include first order and second order measures for the layout in each of their different evolving stages, applicable at global scale, as well as to the structuring traces of the system, providing a syntactical evaluation of its evolution.

A distinction is made for the set of global attributes and those concerning the main integrating lines, that form a isolated in this study in order to see its contribution to the area and evaluate its relative importance. The data inform us that NC go on increasing until 1714, remaining constant up to 1862, and decrease drastically until today. A proposal produced in 1932 by the group Gatcpac indicates the trend followed later: the Old City has lost residential density, has mixed land uses (services – cultural, administrative, catering-, etc.). A similar process is shown for the core, even more pronounced.

Stage	**Set attributes**							
	NC	**m. conn**	**m. depth**	**m. int (R3)**	**m. int (Rn)**	**intel (R3)**	**intel (Rn)**	**synergy**
1439	572	4,7063	6,5524	2,0967	1,2156	0,5396	0,2244	0,5278
1714	588	4,6295	6,7470	2,0583	1,1798	0,5672	0,2515	0,5385
1858	586	4,9727	5,5610	2,1905	1,5150	0,5109	0,2746	0,7093
gatcpac	465	5,7677	4,5280	2,4446	1,8516	0,5223	0,3211	0,7624
2009	518	5,6680	4,5522	2,4106	1,8785	0,5341	0,4048	0,8373
	Core attributes							
	NC	**m. conn**	**m. depth**	**m. int (R3)**	**m. int (Rn)**	**intel (R3)**	**intel (Rn)**	**synergy**
1439	45	10,5435	5,6795	2,7343	1,4438	0,7072	0,2062	0,4364
1714	48	10,4468	5,9418	2,7060	1,3842	0,7208	0,2377	0,5025
1858	40	10,5000	4,7756	2,7945	1,8202	0,7242	0,5438	0,8617
gatcpac	30	13,0333	3,8318	3,1313	2,2789	0,7052	0,4364	0,7787
2009	33	12,2647	3,8640	3,0892	2,3131	0,7578	0,5435	0,8082

Tab. 1 Syntactic attributes of different stages in Old City and its core/ supergrid.

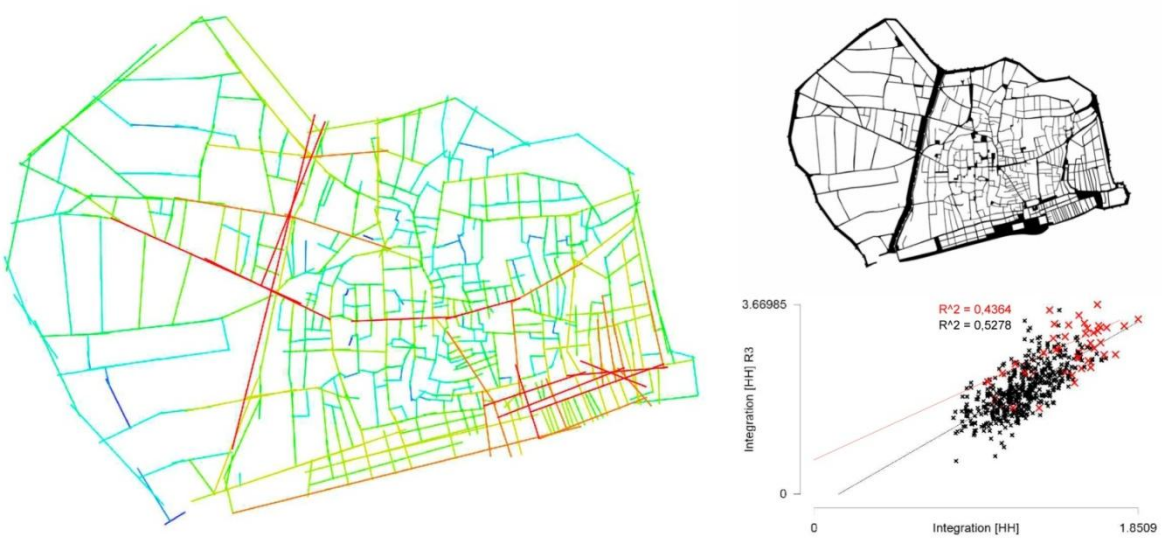

Fig. 5CiutatVella in 1439.Axial mal showing integration [HH] R3. Plan of open spaces. Scattergram showing synergy between selected lines (core grid) embedded within the contextual area.

As we can see in figure 5, the scattergram shows each line in the whole Old City axial map as a point located according to its value of global integration on the horizontal axis and its degree of local integration on the vertical axis. The red points are the edge-to-centre lines which form the original core of the Old City/ CiutatVella. The black points representing the part of layout with highest local values do not form a good linear scatter with respect to their own regression line, but cross the main regression line at a steeper angle. This spreading indicates a poor relation (0,5278) between local and global integration, the steeper slope across the regression line implying that CiutatVella was more locally (2,0967) than globally (1,2156) integrated at that time; we should bear in mind that the layout studied represents two thirds of its present state today. From this stage (1439), the number of nodes (572) goes on increasing.

A set of lines with the highest values is clearly marked for this period, configurating a typically organic layout. The structural schema acts from a 'supergrid' that operates as 'core' (edge to center), from which the rest of the system is articulated, existing an homogeneous distribution around it. The system's intelligibility is lower from the global level than from the local. In the first case the presence of the 'supergrid' clarifies the general schema against an apparently subjacent complexity in the rest of the organic layout. In the second, an attentive look unveils the hidden order of its organic grid, facilitating its comprehension by locating the "live centres" of original settlements. The measure of 'radius-3' integration picks out the much more localised structure that remains under the movement structure (integration core), that at a global level even shows the sinuous wandering routes that most inhabitants of Barcelona know as the quickest ways from one point to another, following in practice the theory of 'natural movement'.

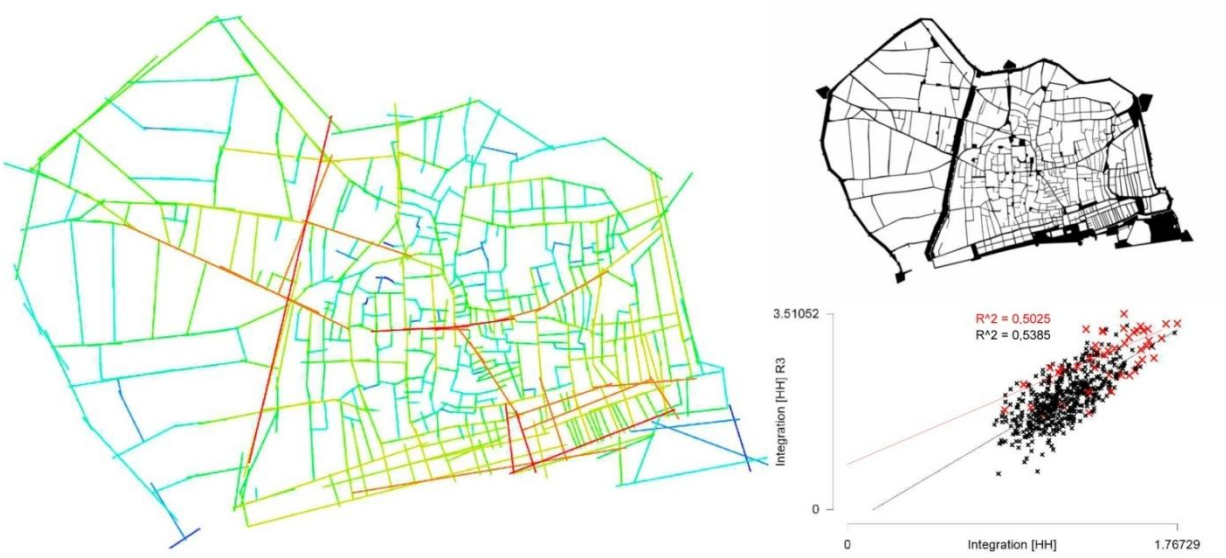

Fig. 6 CiutatVella in 1714.Axial mal showing integration [HH] R3. Open space plan. Scattergram showing synergy for selected lines embedded within the contextual area.

For 1714 as shown in figure 6, the node count reaches a higher value (588). Mean depth has the highest value of the whole series (6,7470), understandablefact, since bad times were about to come: a 17 % of the layout was cut off from the settlement, not recovering its connective and integrative qualities in this part of the city. CiutatVella remains more locally (2,0583) than globally (1,1798) integrated, with a gentler decrease of its value compared to the previous stage.

Moreover, if we plot local against global integration for those lines against a scattergram for the whole of the Old City, its linearity, its slope, and its location in the overall scatter are powerful numerical indicators of the characteristics of an area. The integration core composed of the partial grid of lines that connect edge to centre are the stronger global scale integrator while the interstitial areas are more tied tothe local scale. We find a scatter which is layered rather than linear, what shows a certain degree of segregation in the system.

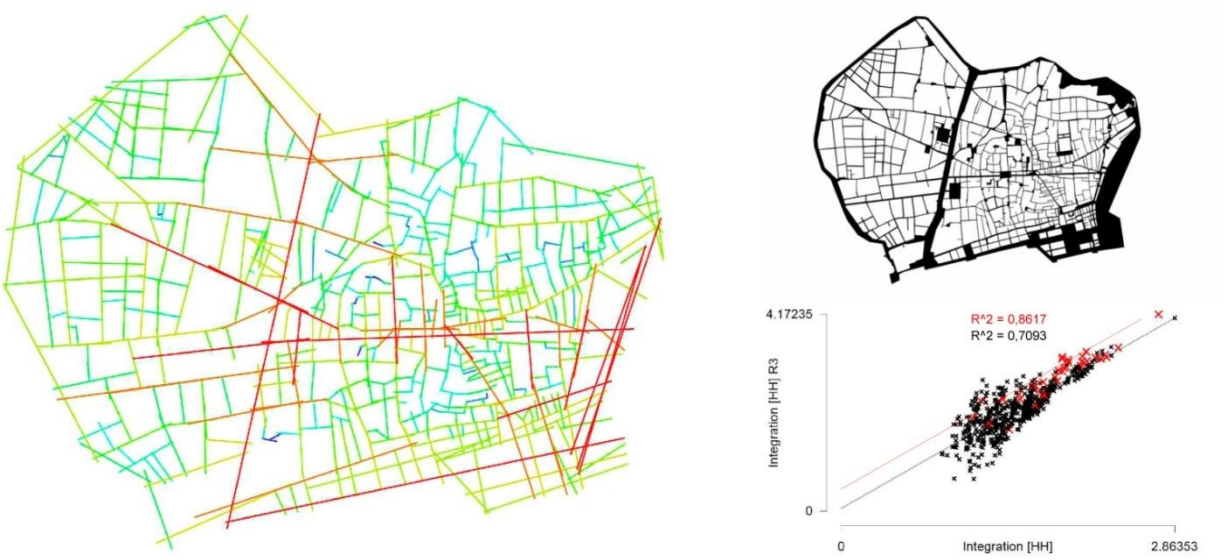

Fig. 7 CiutatVella in 1858.Axial mal showing integration [HH] R3. Open space plan. Scattergram showing synergy for selected lines embedded within the contextual area.

From 1858 (Fig. 7) onwards, the number of nodes(586) decreases, maintaining a value close to that of the previous stage. Old City remains more locally (2,1905) than globally (1,5150) integrated for this period (1858), and new urban trends increase synergy (0,7093) both scales. The lines constitutive of the core show higher synergy than the whole domain of CiutatVella, since the increase in local density in the rest of the layout has little contribution to the intelligibility of the area at a global level, especially in the West sector (Raval). In the scattergrams for this period the regression lines slope show a parallelism and proximity that indicates a similar spatial structure in movementexchanges between inhabitants and strangers; even more, overall movement is close to being substituted by that of the selected core lines, losing opportunities of exchange between different global and local domains.

L**inearity** in new tracings indicates a higher integration on them, reducing depth in nearby spaces at the same time, until a new organic rearrangement is produced. Although this linearity happens in some developments, if the process sets priorities for the most ancient integrated spaces (organic towns principles), it would be enough to make the adjacent lines to the main integrators the most likely locations for the next stage of retail location, developing a clustering or linear distribution, depending on the available structure of space, instead of creating structural 'patchworks'.

An intermediateproposalby GATCPAC (Fig. 8), dated 1932 and never implemented, but with the intention of pushing down densities in Old City sets the path for later undertakings. The value of Node Count is the lowest (465) when compared with the stages studied, but Mean Connectivity (5,7677) is the highest in the series and Mean depth is the lowest (4,5280). This causes the highest local integration R3 and a considerable synergy (0,7624), which, with hindsight, is quite on the line to be followed after all the planning implemented in the 1980's and 1990's guiding to the 2009 situation. It seems a radical proposal, where a strategy is thought and directly implemented, but the axial map shows a clean result if compared with the present situation, stressing the links with the Cerda grid at the Northern part of the Old city and taking profit of already existing lines. The scattergram shows a clear scissor between the correlation lines, a tendency followed later.

Finally, in 2009 Fig. 9, the number of nodes of the system reaches its lowest value in the series of stages analysed. The set of CiutatVella is still better integrated locally, as along the whole process we have followed, although increasing interventions in the layout tend to introduce a new global configuration. Thus, its integration values increase at the same time at local and global scales, reaching a greater synergy value (0,8373), the highest in the four stages studied. In this case, the linearity shown in the scattergram implies a good relation between local (2,4106) and global (1,8785) integration

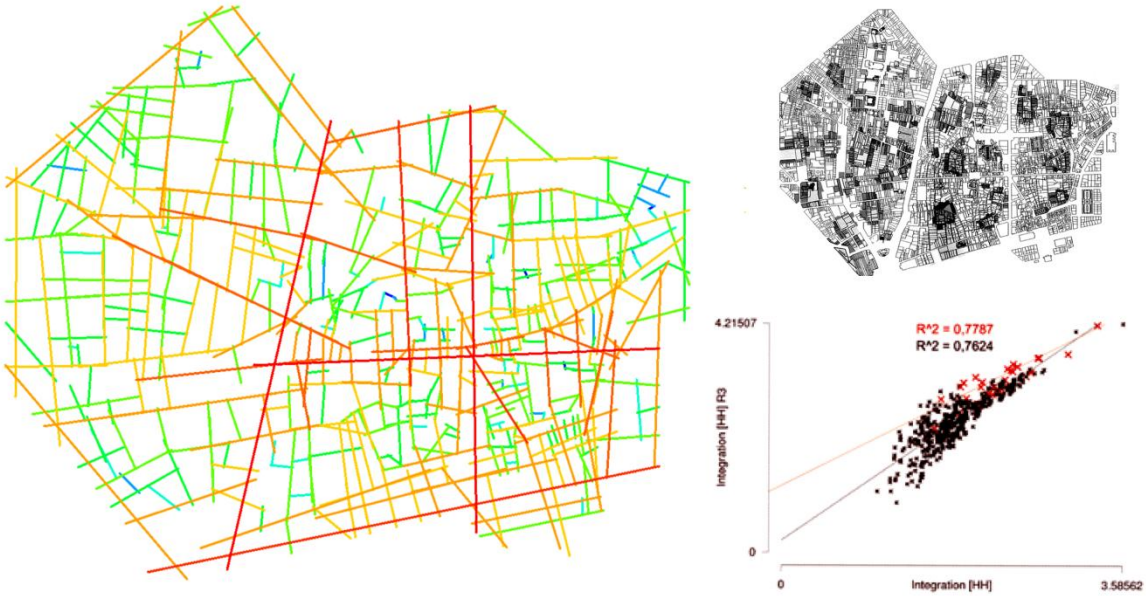

Fig. 8 1932 GATCPAC Proposal for CiutatVella.Axial mal showing integration [HH] R3. Open space plan. Scattergram showing synergy for selected lines embedded within the contextual area.

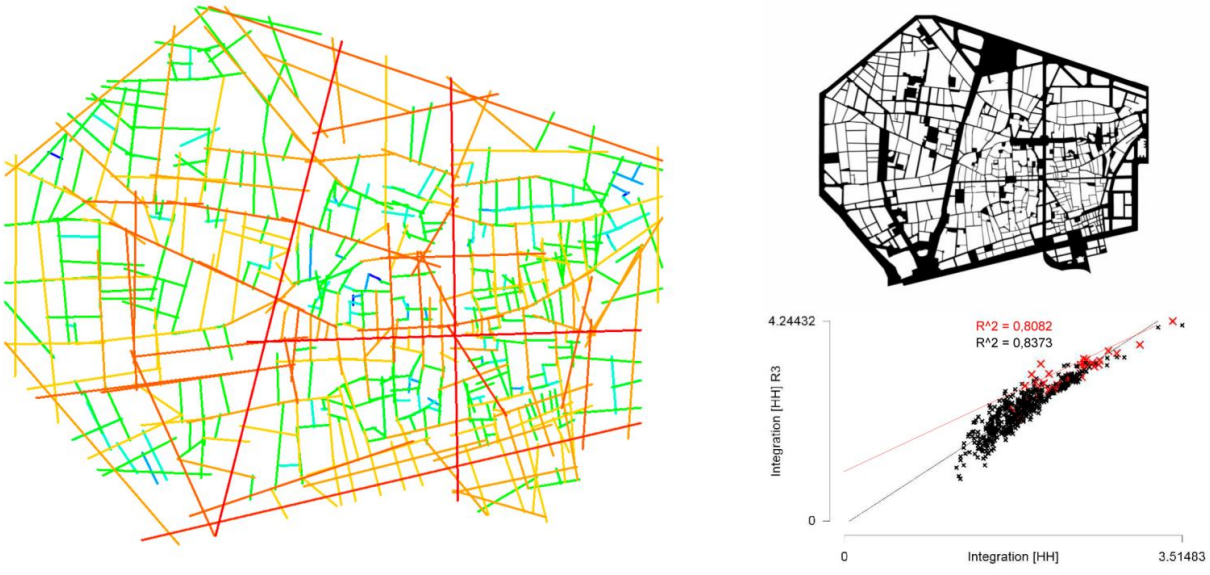

Fig. 9 CiutatVella in 2009.Axial mal showing integration [HH] R3. Open space plan. Scattergram showing synergy for selected lines embedded within the contextual area.

The tendency to clearance interventions through public spaces becomes the "operation" for the most recent period, consolidating the 'essential urban dynamic' by *which grid structure, movement, land use patterns and densities become interrelated. In accordance with the theory of 'movement economy', the urban grid evolves and creates a pattern of movement potentials, and, to some degree, movement.* It becomes clear that an urban grid is not simply a framework for human activity, but a record of a historical process based on a dynamic process. Simple intelligibility analysis (Fig. 10) gives a picture of the urban grid, which is informative not only about movement, but also about key integrators, depending on the historical operation of the attractor effect. The 1439 modest compactness is dispersed during the war periods prior to 1714 surrender and connectivity is controlled despite increasing local integration.

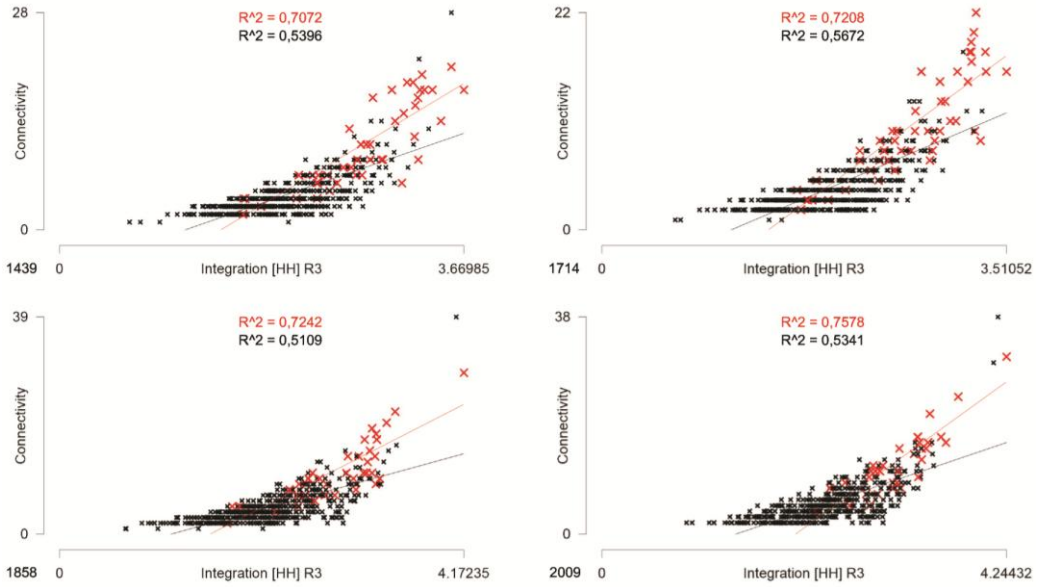

Fig. 10 Scattergrams showing local intelligibility for selected lines embedded within the contextual area at stages considered.

6. CENTER DUALITY.

The dual process of cities functional patterns are tracked: "(...) *the main, local-to-global structure of the grid with its longer lines and (...) patchwork of more local areas with shorter lines and more grid like connections. Thus cities tend to have a universal global form and a culturally specific local form*" (Hillier 2007). The very centre of Old Barcelonaoriented eastbound worked with a restricted local economy, differentiated from big trade linked to port activities, where the layout density was considerable at the time. The remains can be seen clearly in Fig. 11.

Fig. 11 a, b. Axial and segment maps of 1439 Old City. A) Integration R3 with Roman City location. B) Segment map integration R70 metric with Roman City location, marking high values relative to Viles Noves.

Centrality as result of functional and spatial elements is well known. Functional components, with concentration and mixture of activities in a particular area, have their spatial counterpart signalled by the **accessibility** concerning the global level. Accessibility can be estimated here from the value of Choice at different radii. Its coincidence with the values of integration tells us how effectively the system tends to be used. From 1439 to 1714 the relation between Choice and Integration R3 tends to go up a little (R^2= 0,36 for 1439 and R^2= 0,42 for 1714), whilst this relation suffers a big reduction for 1862 and 2009 (R^2= 0,19 for 1862 and R^2= 0,24 for 2009) remaining at a 50% of the 1439 starting value (Fig. 12).

These measures lead us to a first conclusion: recent interventions, regardless of the increase in local and global integration produced for the system in 2009 (See Table 1), have introduced new elements, since the relation between accessibility (Choice) –that tells us about the functional tendency of the grid- and the foreground (local-global relation) show a disagreement.

We can observe at the local scale the same relation with the patchworks as in the values obtained from segment maps with 70 meters radii for Node Count and Choice. In this case the values suffer little or no variations trough all stages (for 1439, R^2= 0,54; for 1714, R^2= 0,50; for 1862, R^2=0,54; for 2009, R^2=0,58) maintaining a constant 50% of agreement (Fig. 13). These results tell us that -contrary to first thoughts- that local values of accessibility for the local scale are maintained almost without mayor changes trough time.

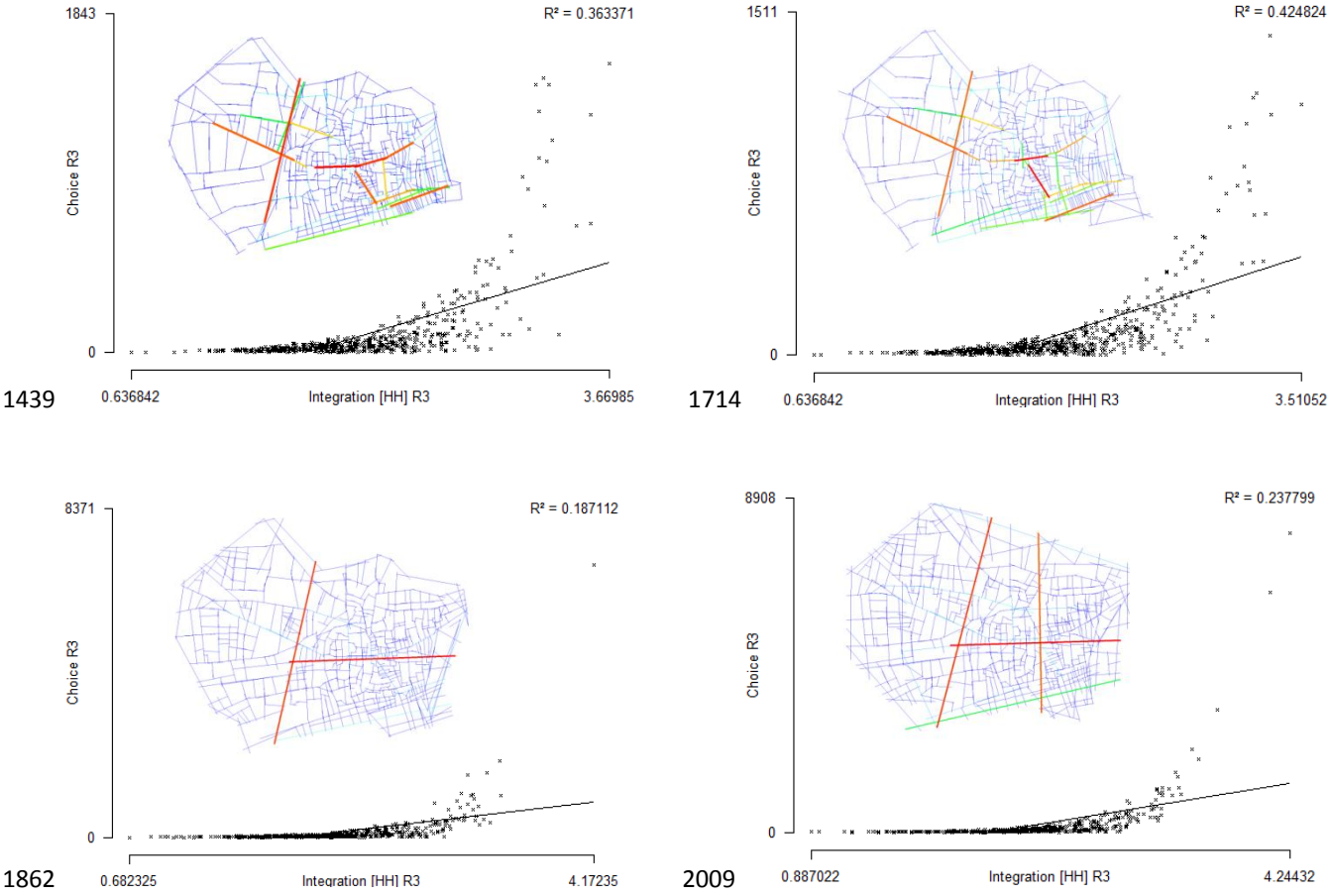

Fig. 12 Axial map for Choice R3 and scattergram between the values of choice and integration for local topologic scale.

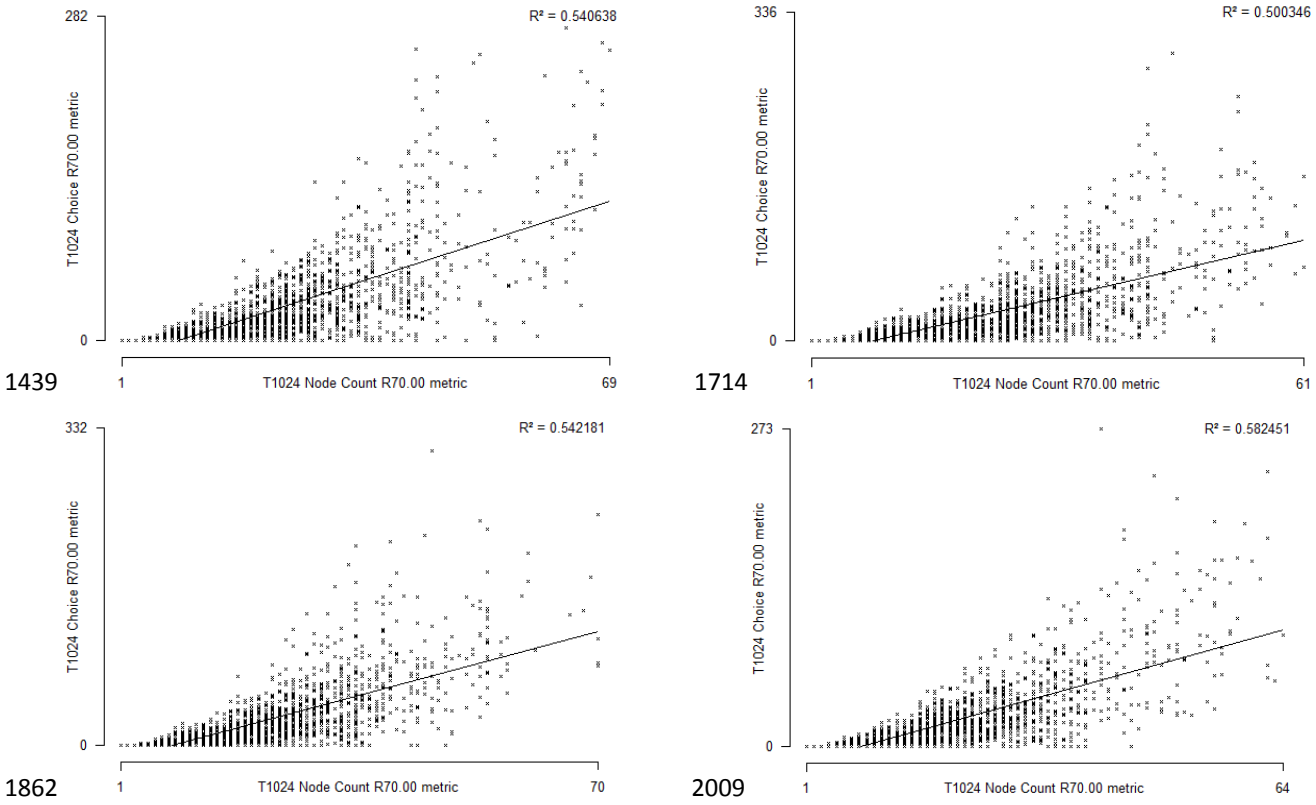

Fig. 13 Scattergrams showing the relation between the local metric values of choice and Integration

Concentration is recognized easily in our area, whilst evidencing the second property of centralities, i.e., its spatial singularities, requires consideration of other results in Depthmap analysis:

The axial map corresponding to integration measure, for the topometric value R3, identifies those structures superimposed to the local domain and link the network as a whole at different scales (Hillier 1999). The main traces can be recognized in the relation local to global link with these measures.

Out of the series of Segment maps produced, that relative to the metric value of radius 70 for the integration measure (checking NC, since MD tends to 1 for local measures) captures spatial differentiations in patchworks or local singularities of the system.

The results from the second point could induce to think that some singularities could be verified at a local scale for the layouts studied, but we need to complement these observation with the results from topological measures, if there existed a coincidence between those lines that connect topologically the local scale given by the metric measure with the global scale, then we would be in front of relevant centralities –for both local and global connections- within the system's configuration.

Observing the superimposition of foreground and background obtained by measures of local and global integration, metric and topological (Fig. 14), we can see that:

The patchworks are really related to the global scale for 1439 and even more so for 1714, since each centrality is complemented with one or several ways of global connection.

This relation is weakening for 1862, however, since most global connection is absorbed with the introduction of Ferran Street, turning several centralities into trivial patches in its immediacies.

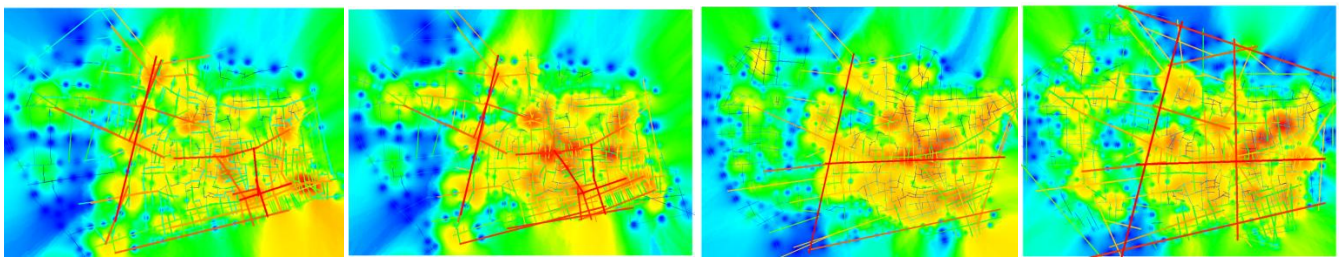

Fig. 14 a, b, c, d.Background (Integration R70 metric) and Foreground (Integration R3 topologic).(1439, 1714, 1862, 2009)

There is a coincidence only at one spot for the present state, 2009, (at the intersection of Ferran and Via Laietana, i.e. Angel's Square) with the highest levels of local integration; again, metric measures only provide "trivial patches" in this case.

7. CONCLUSIONS.

Modifications of the grid and overlapping imposed with different logics to that of the organic layout cause diverse effects at different scales or radius. At global scale we can notice more evident changes than those at a local one; such are the cases of big linear interventions in "Ferran" and "Via Laietana" streets, to be expected. Meanwhile, at local scale the analysis uncovers the particularities of the grid, where a series of lines has the responsibility of channelling most of the connective and integration roles in this part of the city, The phenomenon of pervasive centrality is clearly depicted, since there is no longer an only centre, but a collection of them, spread by the metropolitan city. A shift of centre is clearly seen in the axial maps, from East to West, and towards the North, within the Cerdà enlargement.

The task of linking the different sectors is bestowed upon a limited number of lines, some organic and with a long history, others (Ferran) with changing qualities, absorbing the task previously developed by the curve distributor connecting the most important centres in Old City. Land uses have changed drastically, and, as we can see by the big decrease in Node count, residence is no longer dense, and new cultural and administrative uses establish a new pattern.

Data concerning Choice, the remains of old patchworks have not been fully developed owing to the size of this paper, but the image constructed is that relations between local and global scales tend to homogeneity, where an infrastructure of mixed uses enables survival, by optimizing performance, continuing with a long tradition of achieving the maximum possibilities with a relatively modest core.

Overlapping provided by History and the reality of daily-life show that the organic pattern covers most of the task required in this urban layout, where some originally inorganic lines have achieved a vital, organic duty, and others have introduced evident segregation.

ACKNOWLEDGMENTS

Research accomplished with the help of a grant from the Spanish Ministry of Education.

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